1884MNRAS..44..297D

usually termed perfectly instantaneous. Certainly it did not occupy ·2 of a second, but I thought it took place by a gradual diminution of brightness, although the time was so very short. Reappearance unseen, because at that time clouds covered the Moon.

18 *Preston Street, Brighton.*

The Radiant Points of Fireballs. By W. F. Denning.

There are certain dates of the year when fireballs have displayed a marked ascendency, and when their radiant points have become determinable from the path directions of such as have been accurately recorded. The catalogues of various meteor observers comprise a large number of these observations, though the relative proportion of meteors equalling or exceeding *Jupiter* is somewhat less than three per cent. of the aggregate number registered. In addition to this source of information there are the Annual Reports of the British Association Committee on Luminous Meteors, in which are published a large number of important computations (chiefly by Prof. A. S. Herschel) in connection with the heights, velocities, and radiant points of fireballs. Combining these results with my own and other observations of meteors during recent years, I have endeavoured to find the positions of some of the leading fireball radiants of the year.

In an investigation of this kind many difficulties have to be confronted, for a considerable number of instances are met with where the evidence of certain showers cannot yet be regarded as proved with sufficient distinctness. It is also doubtful, owing in many cases to insufficient materials, as to which are the systems entitled to precedence. There is also another point of signal importance with respect to the *durations* of these displays of large meteors. At first I attempted to group the radiants into very short periods of about two or three nights, but found the observations incompatible with such limited duration. In some well-defined examples they appear to extend over several weeks, and in fact present an analogy to showers of ordinary shooting stars, with which they are no doubt intimately associated; and as further records accumulate, the probable identity of such streams will be yet more closely established. As evidence of the long duration referred to, I may mention the shower in Scorpio (June–July) and Gemini (Nov.–Dec.), which obviously continue in action during a lengthy interval, as the following instances of doubly-observed fireballs (computed by Profs. Niessl and Herschel respectively) will sufficiently prove:—

1884MNRAS..44..297D

Date.	Radiant. α	δ	Date.	Radiant. α	δ
1883 June 3	249°·9	−20°·2	1862 Nov. 27	102°	+26
1883 3	248	−20	1877 Dec. 9	112	+27
1878 7	249	−21	1863 12	105	+27
1873 17	248·6	−20·2	1873 24	115	+38
1879 July 13	246	−19			

The latter is also very rich in October, at the epoch of the *Orionids*, when it furnishes some very swift and, occasionally very brilliant, meteors in the morning sky:—

Radiant Points of Fireballs.

No.	Epoch.	Radiant. α δ	Approximate Star.
I.	Jan. 1–3	230° + 51°	β Boötis
II.	4–12	57 − 12	γ Eridani
III.	Mar. 1–4	300 + 80	κ Cephei
IV.	30–Apr. 7	27 + 18	α Arietis
V.	Apr. 11–12	106 + 46	16 Lyncis
VI.	19–20	274 + 37	α Lyræ
VII.	19–23	258 + 37	τ Herculis
VIII.	19–23	210 − 9	κ Virginis
IX.	29–May 5	335 − 9	θ Aquarii
X.	June 3–7, 17	247 − 25	α Scorpii
XI.	July 25–30	326 − 9	β Aquarii
XII.	25–30	8 + 34	β Andromedæ
XIII.	25–31	338 − 11	δ Aquarii
XIV.	25–31	303 + 12	α Aquilæ
XV.	25–Aug. 1	32 + 53	χ Persei
XVI.	Aug. 9–11	4 + 56	η Persei
XVII.	9–11	12 + 30	β Andromedæ
XVIII.	9–11	335 + 73	β Cephei
XIX.	9–11	284 + 62	ο Draconis
XX.	9–11	312 + 50	α Cygni
XXI.	19–22	330 + 69	β Cephei
XXII.	19–25	291 + 60	δ Draconis
XXIII.	Sept. 1–4	306 + 54	α Cygni
XXIV.	6–15	61 + 36	ε Persei
XXV.	10–25	336 + 35	π Pegasi
XXVI.	Oct. 2	225 + 52	β Boötis
XXVII.	15–22	92 + 15	ξ Orionis

1884MNRAS..44..297D

No.	Epoch.	Radiant. α δ	Approximate Star.
XXVIII.	15–22	106° + 23°	ϵ Geminorum
XXIX.	17–22	40 + 20	ϵ Arietis
XXX.	17 26	247 + 41	η Herculis
XXXI.	25–Nov. 7	48 + 22	ϵ Arietis
XXXII.	Nov. 5–8	58 + 16	γ Tauri
XXXIII.	12–14	148 + 23	γ Leonis
XXXIV.	19–23	62 + 22	ϵ Tauri
XXXV.	27	29 + 46	γ Andromedæ
XXXVI.	Dec. 6–8	80 + 23	ζ Tauri
XXXVII.	6–12	106 + 32	α Geminorum.

Several of the above showers ought perhaps to have been coupled together as identical. XV. is certainly an early display of the Perseids (XVI.). The Andromedes (XII. and XVII.), Cepheids (XVIII. and XXI.), Draconids (XIX. and XXII.), Cygnids (XX. and XXIII.), Muscids (XXIX. and XXXI.), and Taurids (XXXII. and XXXIV.) are so nearly conformable to the same respective positions that it is impossible to resist the inference that these pairs are closely allied, if not actually connected, with each other.

I have solely relied on my own observations and reductions for the positions given in the table. In cases where the same radiant has been determined by other observers the agreements are usually very satisfactory, though not, in two or three instances, as close as might be expected. Thus No. IX. is Col. Tupman's shower of May 2, 1870, which he placed at 325° − 2½°, so that there is a difference of about 11° between the two results. The June shower in *Scorpio*, which seems a very important one, is given by Prof. Niessl at 248° − 20,* but I judged it to lie at 247° − 25° from the large fireball which I, in common with many others, observed on June 7, 1878, $9^h\ 50^m$. The July Aquariads (Tupman, No. 43), at 341° − 13°, which returned with great activity in 1878 and few following years, are doubtless identical with the fireball radiant No. XIII., which has been derived from a variety of sources. I have not included in the list such radiants as have been ascertained by duplicate observations of isolated fireballs, of which there are probably some hundreds. It will be found, however, that many of the showers now given receive close confirmation from such observations. As to the showers in *Perseus* (No. XXIV.), in *Musca* (No. XXXI.), and near ζ *Tauri* (No. XXXVI.) they seem to have escaped special

---

* *Astronomische Nachrichten*, No. 2566. Prof. Niessl's computation of the position of this radiant is probably very exact as the several observations of large fireballs which he has discussed show an excellent corroboration.

1884MNRAS..44..297D

notice until the last few years, although they severally furnish displays of considerable richness.

In addition to the centres included in the summary, there are other showers which unquestionably deserve a place, though it seems necessary not to deviate from the original plan of giving none but those of the most prominent character. One or two instances may, however, be adduced as representatives of a numerous class:—

January 12–19, from *Cancer*.—The large fireball of Jan. 12, 1879, had a radiant at 133°+19°. Another fireball, seen on Jan. 19, 1877, was directed from 135°+27°, and probably emanated from the same system.

February–March.—Some large fireballs from *Sextans* (145° +6°).

March.—Fine meteors diverge from S. of *β Leonis* (175° +14°).

May 30.—A fireball radiant in *Cassiopeia* (18°+58°).

June–July.—Several fireballs from the northern limits of *Sagittarius* (285°−12°).

Such references to showers more or less certainly established from past observations might be greatly extended through each of the last six months of the year, until on Dec. 30 we come to a display from the extreme north-east region of *Auriga* (92°+57°), to which the great meteor of Dec. 30, 1878, owed its origin.

There is also a notable fireball epoch on Feb. 7–10 and Dec. 21, but I have failed to discover the places of radiation from a sufficient number of observations.

I had intended to annotate the positions included in the table, with remarks explanatory of their probable strength and the sources of corroboration, but the addition of such matter must have extended the paper to considerable length beyond its purpose. It will be noticed that all the well-known periodical showers are represented in the list. I found it necessary to include them, as they have each, at their several epochs, supplied many fine meteors, though neither the Orionids or Andromedes are remarkable for their fireballs. The special nights of recurrence of all the chief periodical showers are, however, those upon which very extended watches have been kept, and when the rich showers alluded to have asserted their supremacy over the more attenuated contemporary displays not only as regards shooting stars of normal aspect, but (from their much greater intensity) as regards large meteors also.

At some epochs prolific in fireballs, such as those of March 1–4 and April 11–12, it has been found difficult to decide as to the principal radiant point, and the positions adopted in these cases must be understood as provisional, and subject to such alteration as future observations may render necessary. Early in March there are several large meteor showers proceeding from *Leo*, *Ursa*, and *Camelopardus*; and about April 11–12 the observations clearly indicate the positions of three radiants,

1884MNRAS..44..297D

in addition to that given in the list, at 70° + 50°, 159° − 8°, and 18° + 57°. In these and other similar cases the want of additional data is greatly felt; not only is it required in support of showers tolerably well known, but of others whose existence our scanty records have given us only the mere suspicion. Amongst the latter there are probably many important systems, and hence the desirableness of further pursuing these investigations. The present catalogue is preliminary to what it is hoped future observations will enable to be greatly extended and revised. The necessity for closer attention to this interesting branch of astronomy is admitted, and its great significance has long since been recognised.

I believe these fireball radiants are equally numerous with the star showers of ordinary character, and are often identical as regards physical origin. With reference to the Taurids of November I have observed several instances of minute telescopic meteors and of the largest type of fireballs belonging to this shower. The epoch and place of the radiant agree so closely that, notwithstanding the enormous difference of magnitude in the phenomena observed, there can be no question that they are derived from the same original source. With respect to the number of the positions comprised in the list, they might have been greatly augmented by the addition of many streams which have manifested themselves with more or less certainty in recent years. But it seemed desirable to omit these, awaiting further confirmation, and thus avoiding, as far as possible, the risk of pseudo-radiants, or of radiants of such markedly feeble character as rarely to give any visible indication of their presence.

In observations of fireballs there is a great need of uniform and accurate description. Amongst observers so widely different as regards astronomical knowledge, and so variously impressed as to the essential features of such records, we cannot wonder that their results are often very discordant, and sometimes of no practical utility whatever. The observer is generally taken unawares, and seldom manages to obtain good positions of a fireball's track (even if he be practised in such work), unless by means of the enduring streak, which so frequently remains as an unfailing indication of it. But this can only be considered as such in the first few seconds of its projection, before it will have commenced to drift and assume that contorted appearance which is so common a feature of these meteoric afterglows. I have sometimes noticed a considerable drift in fireball streaks, and the grotesque forms they occasionally put on before ultimate extinction are very striking. Observers should, therefore, note the path from the direction of the streak in its primitive stage, and prolong the extremities (in estimating the whole length of the arc traversed by the nucleus) a sufficient extent on marking the course upon a chart or globe. The greatest intensity of the streak invariably occurs at the point of maximum outburst, near

1884MNRAS..44..297D

the end of the visible flight of the meteor, and the streak is often divided into sections or much condensed in certain parts, according to the remarkable fluctuations which frequently occur in the brightness of the nucleus as its derivative source. The point of greatest brilliancy of a meteor will, therefore, be found to conform with the brightest region of the streak. It is always best to give the path in R. A. and Decl. rather than attempt description by certain neighbouring stars, the latter method being less accurate and more troublesome in reference. Nor should the meteor be described by altitudes or compass bearings, unless in cases where correctness is ensured by instrumental comparisons, or where the apparition occurs in daylight or hazy weather, when it is not feasible to otherwise assign places. Ordinary estimations of altitude are enormously in excess, and it is often doubtful, with regard to given compass-bearings, whether they are true or magnetic. Whenever the observer is not sufficiently versed in the constellations to assign the path in any other manner than by random guesses at the altitude and azimuth, it is best to reject such observations, unless by combination with many other results, which may serve as a corrective. By comparing several observations, in which the alt-azimuthal points of a fireball have been carefully measured, they will doubtless exhibit an excellent consistency, enabling the radiant point and other elements to be ascertained with precision; but in general it must be admitted that a uniform method of recording meteor flights by degrees of R. A. and Decl. + or —, is preferable to any other, as avoiding the confusion and troublesome references involved in different modes of description.

The systematic watching for very large meteors, when not undertaken in conjunction with that of ordinary shooting stars, is likely to exhaust the patience of the most enthusiastic observer, and is therefore not to be recommended. Meteoric observations are best followed on the approved plan, which admits the necessity of noting the faintest objects visible. And these observations should be sustained irrespective of special epochs and the paths and durations of meteors registered in a convenient form. What would accelerate the development of our knowledge of fireballs more than perhaps any other circumstance would be the *general* attention of astronomical and meteorological observers, could we command it, to the accurate description of the more salient characteristics of these phenomena. Were such a plan followed a few years would obtain for us an enormous increase in our records, and enable many doubtful points to be cleared up. Observers would do well to practise themselves in this department of research, and to contribute more freely to its slowly accumulating facts. Co-operation in a sphere of this character where the individual objects to be observed are incapable of definite prediction either as regards time or place of appearances is very essential, for even in the

1884MNRAS..44..297D

habitual observation of fireballs a single observer will gather comparatively few materials unless his labours are prolonged over a very long series of years. The work to be thoroughly successful must be undertaken at many different stations. This has, indeed, to some small extent, been already effected, and as the result we have the valuable meteor catalogues of Heis, Schmidt, Zezioli, Weiss, Konkoly, Schiaparelli, Denza, and others. But notwithstanding this diligence at a few isolated observatories, our existing materials are, it must be confessed, deficient in the extreme, and quite inadequate to the purpose of a satisfactory discussion. Such systems of fireballs as we have already been enabled to detect by means of the few scattered data in our possession may be fairly assumed to constitute streams of great importance, and to afford some notable examples of the multitude of such showers which are displayed with more or less distinctness every year.

Bristol, 1884 *March* 15.

Some Remarks on the Chain of Meridian Distances, measured around the Earth by H.M.S. "Beagle" between the years 1831 *and* 1836. By Prof. A. Auwers.

A great difference between some recent determinations of longitudes in the Straits of Magellan and the results, apparently well founded, and regarded as fundamental up to the present day, in the geography and hydrography of South America, obtained by H.M.S. "Beagle" half a century ago, has been the reason of my undertaking some fresh computations concerning the chronometrical measurements of differences of longitudes which formed one of the main objects of the celebrated second cruise of the said vessel, under the command of Capt. R. Fitz-Roy, during the years 1831 to 1836.

Fitz-Roy has given * as the definitive result for the longitude of the "Old Observatory" at Port Famine, which formerly served as the fundamental point for the surveys of Tierra del Fuego, $4^h\ 43^m\ 51^s{\cdot}5$ W. But if we take from Fitz-Roy's results only the difference measured between Monte Video and Port Famine—for which he assumes as the value mostly to be relied upon $58^m\ 58^s{\cdot}68$ according to the ten chronometers most nearly agreeing in the two runs constituting the connection, from Monte Video to Port Desire, and from Port Desire to Port Famine; which value, however, would be diminished by $2^s{\cdot}19$, using the mean of all the 17 and 16 chronometers respectively—and if we substitute for his own result for Monte Video the longitude as determined recently

---

* *Narrative of the Surveying Voyages of His Majesty's Ships "Adventure" and "Beagle,"* Appendix to vol. ii. p. 348.